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The role of credit constraints and government subsidies in farmland valuations in the US: an options pricing model approach

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Abstract The Modigliani–Miller (M–M) theorem of financial asset theory concludes that asset values are independent of financing. In other words, debt-solvency (credit constraints) does not affect asset values. Therefore, using the M–M theorem one can argue that credit constraints in the farm sector (where land is the most important asset) do not affect the value of farmland. However, this proof relies on several arbitrage assumptions that are violated in the case of agricultural assets. This paper examines the effect of debt-solvency and government payments on changes in annual farmland values by state in the United States. Using panel cointergration method, results indicate that farmland values are significantly affected by both solvency and government payments. In addition, the results imply that government payments may affect agricultural asset values beyond the direct effect hypothesized in the literature.

Keywords Farmland values · Pooling · Debt-solvency · Government payments · Panel cointegration

JEL Classification Q14 · Q24 · R14 · R38

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1 Introduction

Land is the most important asset in the farm business and in the farm household investment portfolio. Research into factors that determine farmland values has typically emphasized expected returns, interest rates, and government payments to farmers, among others. However, the linkage between farmland values and agricultural debt has typically been ignored. This exclusion can primarily be attributed to the Modigliani–Miller (M–M) theorem (Modigliani and Miller 1958), which states that asset values are independent of the means of financing (debt or equity). However, the M–M expectations are based on arbitrage assumptions that may not be valid for agricultural asset markets. Credit availability limits an investor's ability to buy and/or sell farmland. Thus, a short-run decline in farmland values may be magnified if credit is restricted. Farmers and investors wanting to take advantage of a price decline in farmland may be prevented from doing so by changes in credit availability.

Additionally, farmland values remain an important part of the agricultural policy debate. Federal farm policy is a direct contributor to farmland value appreciation. Economists have understood for some time that the value of farm program payments is capitalized into land values as these payments become a component of expected future returns (Moss and Schmitz 2003). This study tests the M–M theorem for farmland by examining whether the credit constraint (debt-solvency) of the agricultural sector affects farmland values. The study also examines the role government of payments in farmland valuation.

This study is different from others in several ways. First, it relates the farm investor's investment financing decision to the M–M theorem. Second, following Merton, this study considers how default risk affects interest rates and farmland values. Finally, this study incorporates both the non-stationarity dimension of farmland values [first raised by Falk (1991)] and the panel structure of the data (state level panel data from 1960–2002) relying on recent advances in econometric literature. Data from 48 states (excluding Alaska and Hawaii) across 10 farm production regions [1] are used in this study. These groupings, ten production regions, are widely used by the Census of Agriculture and generally reflect similar agriculture, particularly in the Corn Belt, Lake States, and the Plains States. However, a single State may still encompass different soils and typography.

2 Credit and farmland values modeling literature

The M–M theorem expresses the relationship between asset values and the credit market. The proof of this proposition (M–M, proposition I) is based on

[1] Corn Belt region: includes IL, IN, IA, MO, and OH. Northeast States: includes CT, DE, MA, MD, ME, NH, NJ, NY, RI, and VT, PA. Lake States: includes MI, MN, and WI. Northern Plains: includes KS, NE, ND, and SD. Appalachia States: includes KY, NC, TN, VA, and WV. Southeast States: includes AL, FL, GA, and SC. Delta States: includes AR, LA, and MS. Southern Plains States: includes OK and TX. Mountain States: includes AZ, CO, ID, MT, NV, NM, UT, and WY. Pacific States: includes CA, OR, and WA.

the ability of either businesses or consumers to arbitrage equity for debt. Miller (1988) describes the basic insight as the fact that consumers ultimately own all the assets in the economy whether they are denominated in stocks (equity) or bonds (debt). Thus, the aggregate balance sheet remains unchanged as consumers decide the proportion of each to hold. Given this proposition, farmland values would be independent of the debt position in the farm sector. In general, objections have been raised to M–M invariance based on three concepts: dividend policy, bankruptcy, and taxes (Miller 1988, p. 102) The second of these objections, the possibility of bankruptcy, may have significant consequences for agriculture because of the sector's reliance on debt financing. In addition, the invariance of financing for asset values in agriculture can be questioned on the basis of the arbitrage formulation. In general, new agricultural assets are purchased with either debt or retained earnings. The sector has not been successful in attracting external equity.[2]

Farm credit influences asset values in several ways. First, debt influences profitability through interest costs. Second, debt influences liquidity through debt-servicing requirements (Barry et al. 1981). Barry et al. note that credit reserves are themselves subject to risk, and therefore credit risk must be accounted for in the farmer's total portfolio risk, and in analysis of risk and liquidity management. Each of these components affects liquidity risk, the ability of the borrower to meet cash obligations as they are due.

Merton (1974) examined the structure of interest rates and how default risk affects interest rates and asset values. Specifically, Merton framed the debt contract in the form of an option price. In this formulation, selling a corporate bond is identical to selling a European call option. Under Merton's framework, a corporation raises money by selling bonds that are secured by the corporation's assets. These bonds carry a fixed interest rate, but the return on the bonds is uncertain because of the possibility of bankruptcy. When the bonds mature, the corporation is left with the decision of whether to pay off the bonds and keep the asset, or to default on the bonds and forfeit the corporation's assets to the bondholders. Based on this general framework, the interest rate charged by banks is an increasing function of the debt-to-asset ratio and an increasing function of the variance of the rate of return on corporate assets.

2.1 Empirical model

In order to incorporate the model of corporate debt as proposed by Merton into a farmland-pricing model, one must assume that the capital market between agriculture and the general economy does not allow for the infinite arbitrage of equity for debt. Any capital flowing into agriculture is then in the form of debt. Next, assume that lenders price debt to agriculture based on their opportunity cost of capital and the bankruptcy risk within the option pricing formulation

[2] The relationship between the rate of return on agricultural assets and other investments in risk pricing models (CAPM or the arbitrage pricing model) documents this fact.

proposed by Merton. Given an increase in the relative risk of bankruptcy for agricultural assets, banks would charge a higher interest rate and the value of farmland would decline. Thus, a relative increase in agricultural debt without a corresponding increase in income implies an increase in bankruptcy risk, an increase in the interest rate charged by banks, and a decline in agricultural asset prices. The solvency of the sector is then measured using the debt-to-asset ratio. In Merton's formulation the debt-to-asset ratio declines, the sector becomes less solvent, the probability of default increases, and the interest rate should rise.

In our model, the rental price of farmland is based on the shadow value of farmland. The basic profit maximization problem facing the farm firm is to maximize profit subject to intermediate investments and the value of land. Given that the shadow value of farmland is above the annualized market price of farmland, the producer chooses to purchase additional acres. Also, given the assumption regarding the capital market, assume that the purchase of farmland will be financed by issuing new debt (taking out a loan). The overall model of farm profit then becomes:

$$\begin{aligned} \max_{y,x,D,A,I} \pi &= py - wx - r(D,v)D + GP \\ st \quad & f(y,x,A,I) = 0 \\ I &\leq I_0 \\ D &= D_0 + (A_0 - A)v \end{aligned} \tag{1}$$

where p is the vector of output prices, y is the vector of outputs, py is net of government payments, w is the vector of input prices, x is the vector of inputs, $r(D,v)$ is the interest rate paid on agricultural debt, D is the level of agricultural debt, GP represents a vector of government payments, v is the value of farmland, $f(y,x,A,I)$ is a technological envelope of production possibilities, I is the level of intermediate capital, I_0 is the fixed level of intermediate capital, D_0 is the level of initial debt, and A_0 is the initial land holding. This model is based on the notion that in long run equilibrium, farmland values will equal the discounted present value of future cash rents. In order to develop $r(D,v)$, we note that by the last constraint A_0, I_0, and D_0 along with the value of farmland determine initial wealth

$$E_0 = A_0 v + I_0 - D_0. \tag{2}$$

By the same concept, the value of equity for the current level of land and debt is determined by A, I_0, D and the value of land

$$E = Av + I_0 - D. \tag{3}$$

Taken together, Eqs. 2 and 3 imply the capital constraint in Eq. 1 given that $E = E_0$ which must be true if we eliminate pure arbitrage (if we assume that the farmer cannot instantaneously make himself better off simply by purchasing farmland). Equation 3 also implies that the farm's debt-to-asset position can be written as

$$\delta\left(D, A, I_0, v\right)=\frac{D}{A v+I_0}. \tag{4}$$

The debt-to-asset ratio is a decreasing function of farmland, farmland values, and intermediate investment, but an increasing function of debt. Within this expression, A is a function of D and A_0 by the constraint in Eq. 1

$$A=A_0+\frac{D-D_0}{v}. \tag{5}$$

Thus, assuming that banks use option pricing to set the interest rate, this debt-to-asset position implies that the optimal interest rate charged by the bank is an increasing function of debt and a decreasing function of asset values (Merton 1974). Given the maximization problem in Eq. 1, the equilibrium condition for farmland in Eq. 9 becomes the capitalization formula

$$v=\frac{\frac{\partial \pi}{\partial A}}{\frac{\partial r(D,v)}{\partial D}+r(D, v)}. \tag{6}$$

Assuming that agricultural interest rates are constant, Eq. 10 then yields the typical capitalization of future rents. This formulation is similar to the deterministic approach found in the farmland valuation literature (Moss and Schmitz 2003).

If the effect of additional debt on the interest rate is restricted to a multiplicative relationship, Eq. 6 can be reformulates as

$$v=\frac{\frac{\partial \pi}{\partial A}}{r \alpha(D)}, \tag{7}$$

where

$$\frac{\partial\, \alpha(D)}{\partial\, D}>0, \quad \alpha(0) \geq r_f \tag{8}$$

where r_f is some risk free rate. Using Merton's work it can be argued that the interest rate on debt is only a function of the required rate of return, r_f and the probability of default or solvency.

Taking the natural logarithm difference of each side of Eq. 6 yields

$$d \ln \left(v_t\right)=d \ln \left(\frac{\partial \pi}{\partial A_t}\right)-d \ln \left(r_t\right)-d \ln \left(\alpha\left(D_t\right)\right). \tag{9}$$

Thus, to test for the importance of credit endogeneity, estimate

$$d\ln(v_t) = \beta_0 + \beta_1 d\ln(R_{At}) + \beta_2 d\ln(r_t) + \beta_3 d\ln(DA_t) + \beta_4 d\ln(GP) \quad (10)$$

where R_A is returns to farmland, r is the average interest rate on farm borrowing, DA is the debt-to-asset ratio and GP represents government payments.[3]

3 Cointegration model with panel data

The theoretical model presented in Eq. 10 can be estimated using a variety of procedures. This study uses a recent innovation in the cointegration literature, namely estimation of panel data models. In particular, the cointegrating relationship will be estimated using panel data as described in Baltagi and Kao (2000). Panel data sets possess several advantages over conventional cross-sectional or time-series data sets (Hsiao 2002). The study data set includes both cross-sectional (e.g., state-level) information as well as time-series information on farmland values, returns to farmland, interest rates, debt-to-asset ratios, and government payments. Based on the panel structure of the data, the cointegrating relationship presented in Eq. 10 is estimated using dynamic ordinary least squares (DOLS) estimated with NPT 1.3 (Kao and Chiang 2000).

To test for cointegrating [4] relationships first estimate β, ρ the estimated autoregression coefficient for the linear relationship, and $\hat{e}_{it}$ the estimated residual, using ordinary least squares and then compute the DF(Dickey–Fuller) tests for $\rho . DF_{t_\rho}$ is a t-test for the autoregressive coefficient. DF_ρ is a Dickey–Fuller test based on the assumption of strong exogeneity. Both DF_ρ^* and $DF_{t_\rho}^*$ allow for the possibility of endogenous regressors. Implicitly these procedures work best if N/T becomes large.

4 Data

This analysis uses US Department of Agriculture, Economic Research Service state-level data for 48 states (excluding Alaska and Hawaii) across 10 farm production regions from 1960 to 2002. These annual data on land values, interest rates, returns to farm assets, government payments, and debt servicing ratios are derived from a variety of sources such as the Census of Agriculture, various USDA agencies, Federal Deposit Insurance Corporation (FDIC) call reports, and the Farm Credit System. All prices and income are deflated using the Personal Consumption Expenditure Component of the Implicit Gross Domestic Product deflator. This study defines the return to farmland as the gross revenues per acre less the expenditures on variable inputs as described by Erickson et al. (2003). This definition is less complete than the alternative

[3] Approximating $d\ln(v_t) = \ln(v_t) - \ln(v_{t-1})$ as in Moss (1997). This allows for the inclusion of stochastic future revenues accruing over the asset's life.

[4] For additional recent work on panel cointegration tests, see Levin et al. (2002).

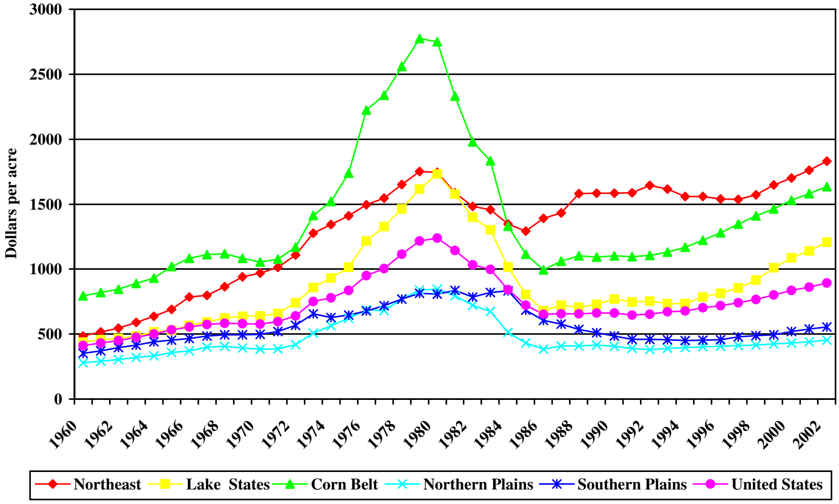

Fig. 1 US and regional farmland values

specification (i.e., the definition of returns offered by Melichar (1979). However, as demonstrated by Mishra et al. (2004), these more complete formulations of imputed returns may introduce measurement error problems if other quasi-fixed assets or labor are trapped in agriculture. Average real interest rate is the average interest rate on farm business debt (i.e., ratio of interest expenses minus interest expenses associated with operators dwelling expenses to average farm debt).

Figure 1 shows the historical trends in average farmland values from 1960 through 2002 for selected farm production regions and for the entire United States. The overall pattern for the various regions is similar, but the magnitude of the fluctuations during the boom/bust cycle (1970 through 1985) is magnified, particularly for the Corn Belt and to a lesser extent for the Lake States regions. The regional differences cannot be explained by the dominance of government program supported crops in the Corn Belt and Lake States in contrast with the pattern for the Northern and Southern Plains where program crops are also dominant. The explanation for these differences is obviously more complex.

5 Results

A modified Baltagi et al. (1996) procedure to pool across observations rather than across years was used to test for pooling across regions. Using this test the data pooling procedure cannot be rejected at any conventional level significance. Following the standard approach to cointegration, we first test each state level data series for non-stationarity using both the augmented Dickey–Fuller and Phillips–Perron tests. In the preponderance of cases these results reject non-stationarity in levels and fail to reject stationarity in first differences

Table 1 Panel test for unit roots

Test	Land values	Returns to farmland	Real interest rate	Debt service ratio	Government payments
Without intercept or trend	0.61(0.2724)	−0.05(0.4983)	−26.24(0.0000)	−0.20(0.4225)	−9.74(0.0000)
With intercept, Without trend	0.15(0.4406)	−15.77(0.0000)	−6.90(0.0000)	−1.92(0.0272)	−14.95(0.0000)
With Intercept and trends	−49.02(0.0000)	−49.17(0.0000)	−9.02(0.0000)	−44.82(0.0000)	−39.39(0.0000)

Numbers in the parenthesis are *p*-value.
Source: Author's computations using NPT 1.3

Table 2 Augmented Dickey–Fuller stationarity tests for panel data

Variable	$\bar{t}_{NT}$	$P[\bar{t}_{NT} \geq c^*]$
ln(land values)	0.533	1.000
ln(return to farmland)	0.212	1.000
Interest rate	−1.568	0.251
Debt service ratio	−0.414	1.000
Government payment	−0.837	0.999

(results available from the authors on request). Thus, a panel approach to cointegration appears to be appropriate. Next, we test for non-stationarity using the panel estimator described above. These results indicate that the data are non-stationary in the panel with heterogeneous intercepts and without a time trend (Table 1). The exception appears to be land values which are non-stationary with a time trend.

To test for non-stationarity in the presence of non-spherical errors we use Im, Pesaran, and Shin's (2003) study to specify the augmented Dickey–Fuller regression for the panel.[5] Results show that the hypothesis of stationarity is rejected at any conventional level of confidence (see Table 2). Using the augmented Dickey–Fuller test a linear relationship can be estimated for each potential regionalization using ordinary least squares, and then the residuals used to test for the presence of a cointegrating relationship for each panel specification. The results presented in Table 2 support the existence of at least one cointegrating relationship for each regionalization at any conventional confidence level. The only possible exception is the Lake States region (which includes Michigan, Minnesota, and Wisconsin).

Accepting the existence of at least one cointegrating relationship in each region, the cointegrating relationship normalizing on farmland values was estimated using DOLS (Table 3). The standard asset pricing literature sug-

[5] Specifically, we estimated the appropriate lag length for each data series and state using the AIC. The results indicated that the appropriate lag length was generally two with land values requiring more lags. Given that relatively less information is lost by overfitting the time series process, we then specified a third-order model, allowing the estimated parameters (other than the first-order term) to be different for each state.

Table 3 Estimated cointegrating vectors and tests statistics for cointegration

	Corn Belt	Northeast	Lake States	Northern Plains	Appalachia	Southeast	Delta States	Southern Plains	Mountain States	Pacific States	United States
Returns to farmland	0.0476	0.8097	0.2942	0.8004	0.4737	0.7803	0.4765	0.4082	0.7265	0.9289	0.6996
t-Ratio	0.4559	11.5395	2.0415	11.2063	4.2937	9.4142	6.9266	3.3969	10.2860	9.7905	19.8029
Prob(T)	0.3247	0.0000	0.0219	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000
Prob(N)	0.3242	0.0000	0.0206	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
Real interest rates	−9.0428	−3.2344	−5.3704	−4.7531	−6.6520	−4.0355	−3.3521	−6.3841	−2.9738	−0.2782	−4.3291
t-Ratio	−5.9257	−3.3769	−2.6286	−5.0872	−5.1961	−4.9926	−3.5573	−5.3777	−3.2713	−0.3003	−10.2671
Prob(T)	0.0000	0.0004	0.0050	0.0000	0.0000	0.0000	0.0003	0.0000	0.0006	0.3823	0.0000
Prob(N)	0.0000	0.0004	0.0043	0.0000	0.0000	0.0000	0.0002	0.0000	0.0005	0.3820	0.0000
Debt-to-asset ratio	−0.0366	−0.0766	−0.0470	0.0153	−0.0310	0.0016	−0.0004	−0.0029	−0.0335	−0.0100	−0.0397
t-Ratio	−4.0928	−8.3217	−3.6087	2.1012	−2.2368	0.2921	−0.0569	−0.1742	−4.5128	−1.3715	−11.7303
Prob(T)	0.0000	0.0000	0.0002	0.0187	0.0133	0.3853	0.4774	0.4312	0.0000	0.0867	0.0000
Prob(N)	0.0000	0.0000	0.0002	0.0178	0.0126	0.3850	0.4773	0.4309	0.0000	0.0851	0.0000
Government payments	−0.1131	4.0122	0.8444	−0.3585	−1.8784	−2.0001	−1.2701	−1.5415	−1.3641	−3.2113	−0.8205
t-Ratio	−0.2193	1.7213	0.7655	−1.0611	−1.5947	−3.6712	−2.9971	−2.4252	−2.0485	−5.0012	−3.3545
Prob(T)	0.4134	0.0430	0.2229	0.1453	0.0563	0.0002	0.0017	0.0092	0.0207	0.0000	0.0004
Prob(N)	0.4132	0.0426	0.2220	0.1443	0.0554	0.0001	0.0014	0.0077	0.0203	0.0000	0.0004
R^2	0.6535	0.6405	0.5026	0.8482	0.4399	0.7198	0.5796	0.7238	0.6831	1.0600	0.7273
Adj. R^2	0.5540	0.1030	0.2633	0.2651	0.3024	0.6098	0.2481	0.6579	0.3397	0.3414	0.0217
SSE	0.1453	0.1505	0.1805	0.0820	0.1456	0.0570	0.0689	0.0932	0.1665	0.0806	0.1413
DF_ρ	−0.7565	−2.1558	0.7116	−3.7442	−1.5745	−5.7206	−3.0375	−2.4369	−3.0735	−1.9262	−7.6297
Prob	0.2247	0.0156	0.2383	0.0001	0.0577	0.0000	0.0012	0.0074	0.0011	0.0270	0.0000
DF_{t_ρ}	1.0038	9.2175	2.4300	0.5526	2.9728	−0.0888	0.0151	−0.9722	4.9402	0.3226	44.5628
Prob	0.1577	0.0000	0.0075	0.2903	0.0015	0.4646	0.4940	0.1655	0.0000	0.3735	0.0000
DF^*_ρ	−2.4758	−4.2386	−0.4274	−6.5157	−4.1417	−10.7386	−5.3844	−5.3781	−6.2639	−4.0296	−11.6744
Prob	0.0066	0.0000	0.3345	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$DF^*_{t_\rho}$	−1.2105	−2.2804	−0.1417	−2.4905	−1.4884	−2.8687	−2.0155	−1.9189	−2.6697	−1.7590	−4.6146
Prob	0.1130	0.0113	0.4437	0.0064	0.0683	0.0021	0.0219	0.0275	0.0038	0.0393	0.0000

Source: Author's computations using NPT 1.3

gests that the estimated coefficients on the returns to farmland be one, the estimated coefficient on the real interest rate be negative one, and the estimated coefficients on the debt-to-asset ratio and government payments be zero. The latter results imply that the M–M theorem of asset pricing holds and that income resulting from government transfers affects farmland values exactly like income from the market. In general, the results depicted in Table 3 indicate that the returns to farmland have a positive effect on farmland values and that farmland values decline with an increase in the real interest rate. Further, both the estimated coefficient on the debt-to-asset ratio and the share of government payments tend to be statistically significant for most regions indicating that the standard application of asset valuation models is insufficient to explain the long-run equilibrium between land values, returns to farmland, and real interest rates.

The results indicate that the estimated effect of returns to farmland on real land values is positive and statistically significant at the 0.05 confidence level for the United States and nine of the individual regions. Curiously, the Corn Belt is the only region where the relationship between returns to farmland and farmland values is not significant at the 0.05 confidence level. This result is curious because this region is typically most closely identified with commercial agriculture in the United States. However, apart from the significant positive relationship between the rate of return to farmland and the real value of farmland, the estimated parameters are less than the anticipated values (e.g., it was anticipated that the estimated parameter would be equal to one). One possible reason for a coefficient less than one may be the relative risk associated with agriculture. Specifically, using the certainty equivalence formulation of relative risk (Moss et al. 1989), the difference between the estimated coefficient and one could imply a risk premium. Under this interpretation agriculture in the Pacific States (e.g., California, Oregon, and Washington) is less risky than agriculture in the Lake States (e.g., Michigan, Minnesota, and Wisconsin). However, this interpretation is also dependent on the possible effect of the solvency of agriculture discussed below.

The estimated effect of real interest rates on real asset prices is uniformly negative and statistically significant with the exception of the Pacific States. Again, the estimated results are consistent in sign and statistical significance, but the relative magnitudes of the estimated coefficients appear somewhat incongruous. Like the case of the coefficients on returns to farmland discussed above, this difference may be partially attributed to relative risk. For example, an alternative formulation of risk other than the certainty equivalent approach is the risk adjusted discount rate approach (RADR). If the capital market for investment alternatives is in equilibrium, then the capital asset pricing model (Mossin 1966; Lintner 1969) implies that the rate of return on a more risky asset must be higher than the rate of return on a less risky asset. This equilibrium can be demonstrated by either an increase in the discount rate applied to the investment or a decrease in the certainty equivalence. Thus, estimated coefficients that are more negative than anticipated may simply imply a higher relative risk.

Alternatively, the difference between anticipated and theoretical results may be the result of measurement error in the real interest rate. In this application, the real interest rate is computed as the natural logarithm of the nominal interest rate computed from the balance sheet and income statements less the logarithmic difference in the personal expenditure component of the implicit gross domestic product deflator. Setting aside the potential measurement error from this measure of inflation, the most probable source of measurement error comes from the use of the balance sheet and income statement to derive the nominal interest rate. Specifically, the appropriate discount rate for use in an asset-pricing model is a forward-looking marginal opportunity cost of capital. The balance sheet and income statement, on the other hand, yield a historical weighted average cost of capital. To the extent that this measure may understate the true forward-looking cost of capital, the potential measurement error introduced could cause the estimated coefficient to be more negative than anticipated.

Both of these results, however, must be viewed within the context of the estimated coefficients on both the debt-to-asset level and the share of income received as government payments. As indicated above, in the strictest application of the asset-pricing model, both of these factors should have no impact on farmland values. Under the M–M theorem, asset values are invariant to the way an asset is financed (i.e., whether an asset is purchased using debt capital or equity capital, the asset will have the same value). Similarly, the source of income should have no impact on its present value. The empirical results presented in Table 3 indicate that both of these restrictions are rejected for the United States and a preponderance of regions. As depicted in Table 3, increased debt-to-asset ratios result in lower farmland values in nine of the ten regions (with the Southeast as the only exception where the effect is positive, but not statistically significant). The negative effect of the debt-to-asset ratio is statistically significant at the 0.01 confidence level in six of the ten regions (with the exceptions being the Delta States, the Southern Plains, and the Southeast States). Further, the negative effect of the debt-to-asset ratio on farmland values is statistically significance at the 0.10 level of confidence in the Pacific States. Thus, one can conclude that farmland values do not conform to the M–M theorem, or that solvency of the agriculture sector affects the value of farmland. Further, increases in the debt-to-asset ratio (or decreases in the sector's solvency) cause farmland values to decline.

The results for the effect of the share of income derived from government payments are less striking. While the coefficient for the impact of the share of income from government payments on farmland values is negative and statistically significant at the 0.05 confidence level for the United States as a whole, the estimated coefficient is negative in only eight regions (with the exceptions being the Northeastern States and the Lake States) and statistically significant at the 0.05 confidence level in only six regions. Even more disturbing, the positive coefficient in the Northeast region is statistically significant at the 0.05 confidence level. Thus, the results suggest that for the United States as a whole (and for most of the regions within the United States) farmland values are a decreasing function of the share of income derived from government payments. This effect is consistent with the findings of Moss et al. (1989).

6 Summary and conclusions

This study examined whether farmland values in the United States were affected by changes in the sector's solvency. These results indicate that decreases in the sector's solvency (as measured by increases in the sector's debt-to-asset ratio) resulted in significantly lower farmland values. From an economic theory perspective, this result is contrary to M–M theorem that contends that the value of an asset does not depend on how that asset is financed. One possible explanation for the theoretical discrepancy is the lack of efficient debt/equity arbitrage in the farm sector in the United States. The theoretical derivation of the M–M theorem is based on arbitrage between stocks and bonds. Buying stocks and selling bonds or selling stock and buying bonds could rectify any undervaluation in the asset caused by type of financing. Historically, the farm sector in the United States has not been able to efficiently attract equity capital. Thus, the capital needs of the farm sector have largely been financed using debt. Hence, the value of farmland is determined by the cost of debt capital that may be priced using an option-pricing framework as described by Merton. Decreased sector solvency (measured as increased debt-to-asset ratios) could increase the marginal cost of capital leading to lower farmland values. The model allows for this effect by recognizing that the real interest rate variable measures the average historical interest rate. Thus, the solvency variable provides information about the relative change in the marginal real interest rate over time. That is, decreases in sector solvency lead to increases in the marginal real interest rate paid by agricultural borrowers.

From a policy perspective, these results indicate that changes in the sector's solvency may help explain the tendency of farmland values to exhibit boom/bust cycles as described by Featherstone and Moss (2003). The possibility of boom/bust cycles in land values is important for agricultural policies in the United States for a variety of reasons. First, as noted above, farmland has been the dominant asset in the farm portfolio over time. Thus, farmland is important for its ability to serve as a credit reserve [as described in Barry et al. (1981)]. This linkage was apparent during the financial crisis of the mid-1980s. During this crisis, farmers experiencing declining farm income attempted to offset this difficulty in the short-run by borrowing against their equity in farmland. However, concomitant with the emerging cash-flow crisis, farmland values started to decline. Thus, the credit reserve vanished as farmers attempted to draw upon it. This loss of credit reserve magnified the growing farm crisis. The estimated relationship in this study supports this linkage. If the estimated relationship, as hypothesized in this study, is based on a cost of capital effect, the farm crisis experienced in the 1980s can be partially attributed to imperfections in the capital market.

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